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DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES
881 HILLSIDE AREA (OU-1)
TECHNICAL MEMORANDUM NO. 10

Final

Department of Energy
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

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FIGURES

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
BRA	Baseline Risk Assessment
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COC	Contaminant of Concern
CRS	Colorado Revised Statutes
DOE	Department of Energy
EE	Environmental Evaluation
EPA	Environmental Protection Agency
FR	Federal Register
FS	Feasibility Study
GRA	General Response Action
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OSWER	Office of Solid Waste and Emergency Response
OU-1	Operable Unit 1
OU-2	Operable Unit 2
OU-5	Operable Unit 5
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PHE	Public Health Evaluation

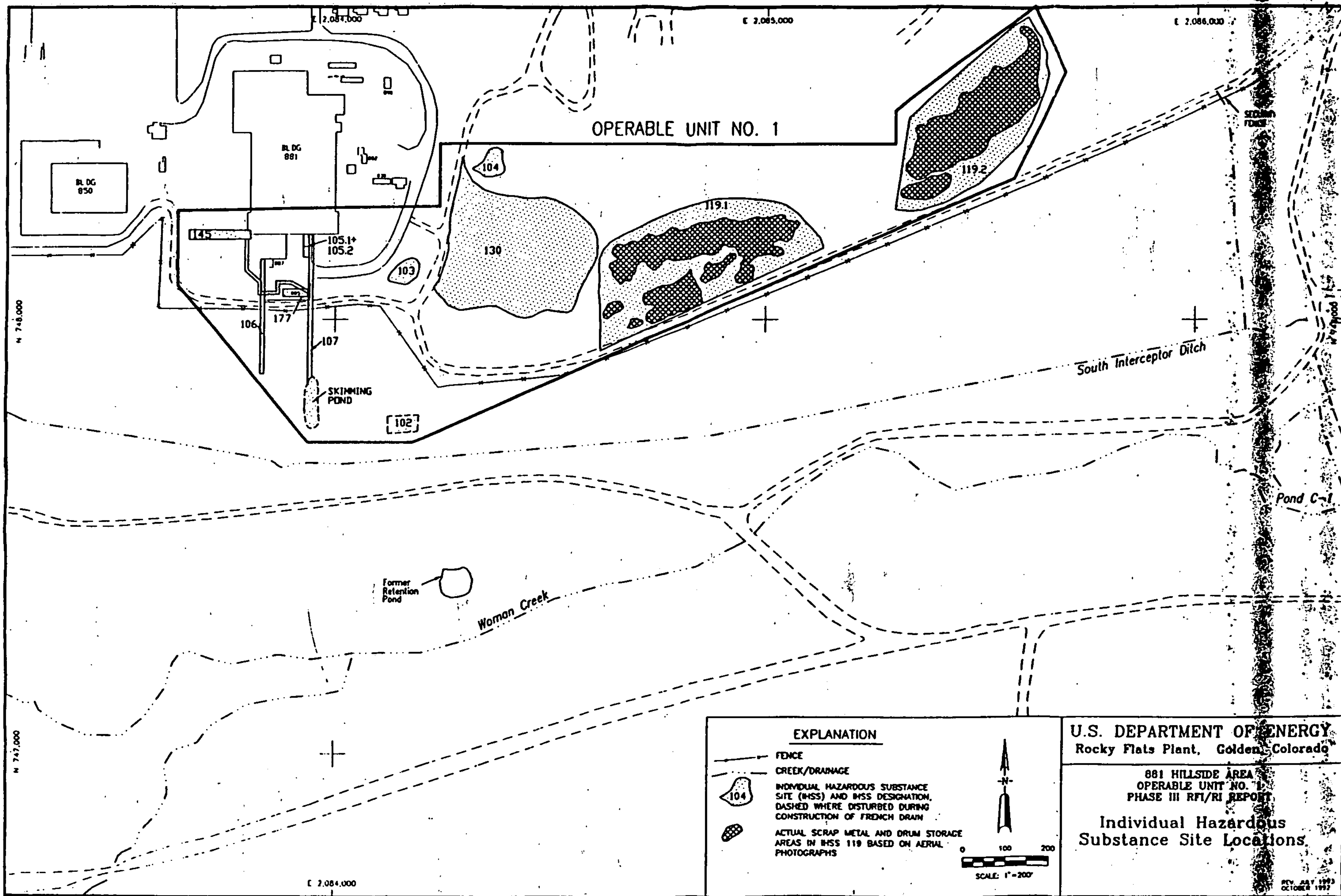
LIST OF ACRONYMS (Continued)

PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFP	Rocky Flats Plant
RI	Remedial Investigation
RRG	Revised Remediation Goal
SID	South Interceptor Ditch
TBC	To-Be-Considered
USC	United States Code
VOC	Volatile Organic Compound

1.0 INTRODUCTION

The purpose of this Technical Memorandum is to document the process by which objectives and goals for remediation were established for the 881 Hillside Area (Operable Unit 1 [OU-1]) of the Department of Energy's (DOE) Rocky Flats Plant (RFP). The memorandum is written in accordance with the *Rocky Flats Interagency Agreement* (IAG) dated January 1991 (IAG 1991). Section IX.A.1 of the IAG statement of work requires that remedial action objectives (RAOs) "...be documented in a technical memorandum to be submitted to the U.S. Environmental Protection Agency (EPA) and/or the State of Colorado for review." As outlined in the IAG, these objectives "...shall specify the contaminants and media of interest, exposure pathways and receptors, and EPA and State accepted levels or ranges of levels for each exposure route." This memorandum includes the information required by the IAG as well as a discussion on the methodology used to develop preliminary remediation goals (PRGs) and revised remediation goals (RRGs) based on the point-of-departure concept described in the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (EPA 1990).

With this in mind, the primary focus of the Technical Memorandum is to present PRGs for minimizing residual risk to human health and the environment which could result from exposure to contaminated soils and/or groundwater related to the operable unit as a whole, or to any of the Individual Hazardous Substance Sites (IHSSs) which make up the operable unit. Figure 1-1 shows the approximate location of these IHSSs, and also the operable unit boundaries. The french drain, installed as an Interim Measure/Interim Remedial Action (IM/IRA) to intercept contaminated groundwater downgradient of OU-1, is located between the OU's southern boundary and the South Interceptor Ditch (SID), running parallel to the SID from a point just west of Building 881, to a point just east of IHSS 119.1. Detailed information regarding the operable unit physical characteristics and the nature and extent of contamination can be found in the *Phase III RFI/RI Report* (hereinafter referred to as the RFI/RI [DOE 1993]).



Reproduced from the November 1993 Phase III RFI/RI Report.

Figure 1-1. Individual Hazardous Substance Site Locations

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

Remedial action objectives are established early in the process of conducting the Corrective Measures Study/Feasibility Study (CMS/FS) as it is necessary to define preliminary goals for a remedial action prior to formulating alternatives for that action. Figure 2-1 is a modified graphic presentation of the CMS/FS process as taken from the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a) (hereinafter referred to as the RI/FS or CERCLA guidance, where the term "CERCLA" refers to the Comprehensive Environmental Response, Compensation, and Liability Act). The figure shows where RAOs and PRGs are established, and illustrates the sequential relationship between the development of RAOs and PRGs and the various phases of the CMS/FS. As illustrated in the figure, until appropriate remedial action objectives and preliminary remediation goals are established, general response actions (GRAs) cannot be developed and combined into remedial action alternatives. The figure also shows that although RAOs and PRGs are established early in the CMS/FS process, PRGs may be modified on the basis of several factors. If required, RRGs are used as substitutes for the initial PRGs.

In order to develop appropriate RAOs and PRGs for OU-1, contaminants which had the potential to pose a significant risk to human health were first identified in the Environmental Evaluation (EE) and Public Health Evaluation (PHE) portions of the Baseline Risk Assessment (BRA). According to the EE, the current concentrations of VOCs in groundwater, and PAHs and PCBs in soils, are potentially toxic to ecological receptors. However, the restricted distribution of these contaminants limits the duration and frequency of contact with receptors and therefore limits exposure. Actual exposure estimations suggest that while some contaminants occur at potentially toxic levels, the contaminated areas are not large enough to result in a significant threat to the populations of plants and animals in the OU-1 area. Based on these results, there are no contaminants of concern (COCs) identified in the EE that would require more stringent PRGs than those presented for human health protection. Therefore, the following sections present the COCs that are identified in the

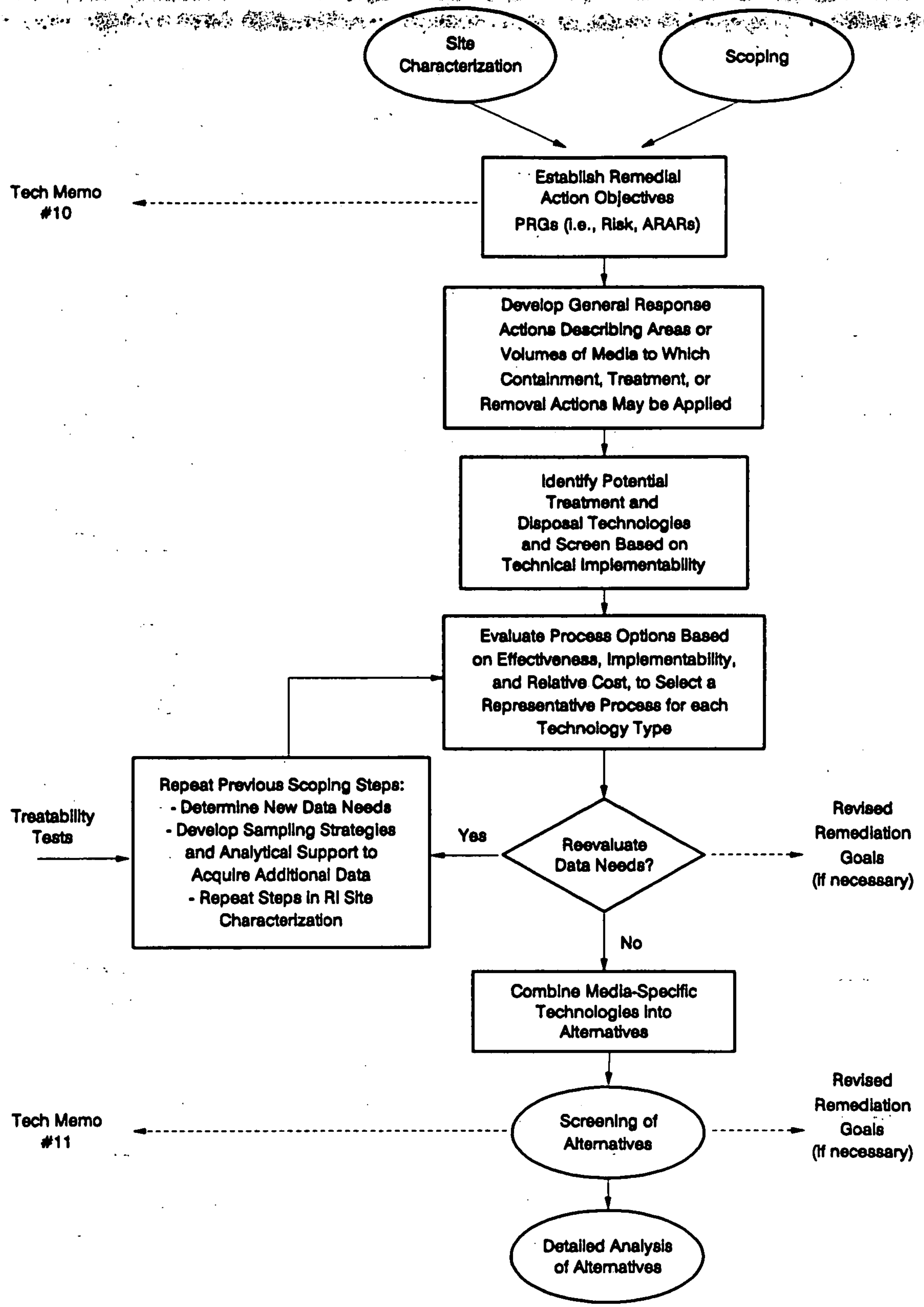


Figure 2-1. CMS/FS Logic Flow Diagram

PHE and the methodology by which RAOs and PRGs were developed.

2.1 Contaminants of Concern by Media

Chemical and radionuclide contaminants discovered during the characterization phase of the RFI/RI for OU-1 were subjected to a multi-level screening process by which COCs were identified for inclusion in the PHE and EE. This screening process narrows the list of potential contaminants which merit further consideration as risk contributors. (The screening process is presented in detail in the RFI/RI report.)

The PHE evaluated contaminant types and exposure pathways that the contaminants would follow, to ascertain the impact that each contaminant could have on present and future human health. As previously mentioned, the results of the EE showed that there were no COCs identified for environmental protection that would require remediation beyond that required for human health protection, therefore only the COCs identified for the PHE are addressed in the following sections. COCs which were found to be potential contributors to the overall risk from OU-1 are listed in Table 2-1. The table includes all of the COCs and media that were originally evaluated in the PHE, however, some of these media do not contain any contaminants in concentrations that result in a carcinogenic risk greater than 10^{-6} or a hazard index greater than one (these media are presented as shaded areas in the table), and therefore do not require evaluation in the OU-1 CMS/FS.

2.2 Potential Exposure Routes (Pathways) and Receptors

During the course of the PHE, site, population, and land use data were analyzed in order to devise several representative exposure scenarios (potentially exposed receptors) for assessing the risk to current and future human health from identified contaminants at the 881 Hillside Area. For each of these scenarios, pathways were traced which represented exposure routes from the source to potential receptors.

Table 2-1.
Contaminants of Concern by Media[a]

Contaminant	Ground Water	Surface Soil	Subsurface Soil[b]	Surface Water[b]	Sediment[b]
Volatile Organic Compounds (VOCs)					
1,1-Dichloroethene	X				
1,1,1-Trichloroethane	X				
Carbon Tetrachloride	X				
Tetrachloroethene	X				
Toluene			X		
Polynuclear Aromatic Hydrocarbons (PAHs)					
Acenapthene		X		ND	ND
Benzo(a)anthracene		X		ND	ND
Benzo(a)pyrene		X		ND	ND
Benzo(b)fluoranthene		X		ND	X
Benzo(k)fluoranthene		X		ND	X
Dibenzo(a,h)anthracene		X		ND	ND
Fluoranthene		X		ND	X
Fluorene		X		ND	ND
Pyrene		X		ND	X
Polychlorinated Biphenyls (PCBs)					
Aroclor-1254		X		ND	X
Inorganics					
Selenium	X				
Radionuclides					
Americium-241		X	X	X	X
Uranium-233,-234		X	X	X	X
Uranium-238		X	X	X	X
Plutonium-239,-240		X	X	X	X

ND = Not detected in the medium.
X = Contaminant is a COC which has been detected in the medium.
[a]COCs cannot be considered final until the results of the RI/BRA are formally published.
[b]Contaminants in these media (shaded) did not result in a cancer risk greater than 10^{-6}, nor a hazard index greater than one.

Pathway elements were examined relative to the results of the Phase III field investigation which indicated that contamination exists in groundwater, surface soils, subsurface soils, sediments, and surface waters. The contaminants identified in these areas included volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), inorganic contaminants, and radionuclides. The contaminant release mechanisms evaluated were leaching, volatilization, resuspension of particulates by wind, etc. Potential transport media identified were surface water, groundwater, air, soil, and biota. The exposure route (the route of entry into the human body) for these media included ingestion, inhalation, and dermal contact. In accordance with the *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation (Part A)* (EPA 1989), if any of the above-mentioned pathway elements is missing, the projected receptor will not receive a chemical or radionuclide dosage and no excess risk will exist from that contaminant.

The results of the BRA indicate that only the media of groundwater and surface soils present a risk greater than the acceptable risk range of 10^{-4} to 10^{-6}. The risk to a human receptor from exposure to groundwater COCs is driven primarily by the exposure routes of ingestion, inhalation of volatiles, and dermal contact. For a future on-site resident, this risk is on the order of 10^{-3} to 10^{-2}.

Likewise, the risk to a human receptor from exposure to surface soil COCs is driven primarily by the exposure routes of ingestion of vegetables, ingestion of soil, inhalation of particulates, and dermal contact. For a future on-site resident, this risk is on the order of 10^{-3}. It should be noted, however, that this risk is based on OU-1 sitewide average radionuclide concentrations. These average radionuclide concentrations include a few areas of high contaminant concentrations (i.e., "hot spots") that are limited in extent and only exist within the boundaries of IHSS 119.1. The risk to a future on-site resident, excluding the hot spots, is actually on the order of 10^{-5}.

Because the media of groundwater and surface soils are the only media which generate a significant risk to human health, they are the only media requiring remedial action evaluation in OU-1. Isolated locations of elevated radionuclide concentrations are considered hot spots which are subject to the RAOs and PRGs presented for surface soils. Table 2-2 presents the concentrations of COCs that were used in the BRA calculations for both sitewide OU-1 (excluding IHSS 119.1) and for IHSS 119.1 alone. Note that the term "sitewide" in the table refers to the OU-1 area. This data was separated since IHSS 119.1 represents an isolated hot spot for both groundwater contaminants and for surface soil radionuclides (one surface soil radionuclide hotspot is located in IHSS 119.2 but is represented in the IHSS 119.1 data set). Other areas of VOC and radionuclide contamination within OU-1 contain significantly lower concentrations than those found in the area of IHSS 119.1.

2.3 Remedial Action Objectives

RAOs are contaminant- and medium-specific goals for protecting human health and the environment. In developing appropriate RAOs, the RI/FS guidance states that "objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited." The guidance also specifies that in order to quantify RAOs, PRGs are developed that provide an identification of what an acceptable contaminant level or range of levels would be for each exposure route of concern. The RAOs for OU-1 are:

1) Prevent the inhalation of, ingestion of, and/or dermal contact with VOCs and inorganic contaminants in groundwater that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6} for carcinogens and/or a hazard index greater than or equal to one for non-carcinogens.

2) Prevent the inhalation of, ingestion of, and/or dermal contact with carcinogenic PAHs, PCBs, and radionuclides in surface soils that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6}.

3) Prevent exposure to carcinogenic radionuclides in surface soil hot spots that would result in an excessive short-term risk to a human receptor.

These RAOs were developed using appropriate regulatory guidelines (i.e., EPA RI/FS guidance and NCP) and by examining the relevant COCs and their associated exposure

Table 2-2
Contaminant Concentrations Used in the BRA[a,b]
(95% Upper Confidence Limit)

Contaminant	Groundwater (mg/L)		Surface Soil (mg/kg)	
	Sitewide w/out 119.1	IHSS 119.1	Sitewide w/out 119.1	IHSS 119.1
Volatile Organic Compounds (VOCs)				
1,1-Dichloroethene	1.62×10^{-3}	$5.96 \times 10^{+0}$	N/A	N/A
1,1,1-Trichloroethane	1.63×10^{-3}	$7.27 \times 10^{+0}$	N/A	N/A
Carbon Tetrachloride	7.98×10^{-3}	$1.84 \times 10^{+0}$	N/A	N/A
Tetrachloroethene	3.10×10^{-3}	$2.03 \times 10^{+0}$	N/A	N/A
Toluene	N/A	N/A	N/A	N/A
Polynuclear Aromatic Hydrocarbons (PAHs)				
Acenapthene	N/A	N/A	1.94×10^{-1}	1.94×10^{-1}
Benzo(a)anthracene	N/A	N/A	3.17×10^{-1}	3.17×10^{-1}
Benzo(a)pyrene	N/A	N/A	3.02×10^{-1}	3.02×10^{-1}
Benzo(b)fluoranthene	N/A	N/A	3.05×10^{-1}	3.05×10^{-1}
Benzo(k)fluoranthene	N/A	N/A	2.89×10^{-1}	2.89×10^{-1}
Dibenzo(a,h)anthracene	N/A	N/A	1.88×10^{-1}	1.88×10^{-1}
Fluoranthene	N/A	N/A	7.26×10^{-1}	7.26×10^{-1}
Fluorene	N/A	N/A	1.92×10^{-1}	1.92×10^{-1}
Pyrene	N/A	N/A	3.49×10^{-1}	3.49×10^{-1}
Polychlorinated Biphenyls (PCBs)				
Aroclor-1254	N/A	N/A	2.76×10^{-1}	2.76×10^{-1}
Inorganics				
Selenium	1.32×10^{-1}	2.96×10^{-1}	N/A	N/A
Radionuclides (pCi/g for soils)				
Americium-241	N/A	N/A	5.73×10^{-1}	$2.22 \times 10^{+3}$
Uranium-233,-234	N/A	N/A	1.30×10^{0}	$2.29 \times 10^{+1}$
Uranium-238	N/A	N/A	1.28×10^{0}	4.66×10^{0}
Plutonium-239,-240	N/A	N/A	3.42×10^{0}	$9.31 \times 10^{+3}$

[N/A] Not applicable; contaminant is not a COC for media indicated.
[a] COCs cannot be considered final until the results of the RI/BRA are formally published.
[b] The numbers presented in this table are subject to change with the publication of the final RI/BRA.

pathways. The PRGs developed for these RAOs are based on current EPA regulations and are discussed in detail in Section 2.4. RAOs were only developed for human health criteria since, as previously discussed, the EE found that there were no risk drivers that warranted remedial action beyond that required for protection of human health. Additionally, since surface soil hot spots do not present a current long-term risk, but do present a potential short-term risk to workers if disturbed, they were included in the development of RAOs.

2.4 Development of Preliminary Remediation Goals

The policy for developing preliminary remediation goals, found in the NCP, is to make use of "readily available information, such as chemical-specific ARARs or other reliable information". Where ARARs or "to-be-considered" (TBC) criteria are not available, PRGs are developed on the basis of a 10^{-6} point-of-departure for risk. This also applies when ARARs are not considered sufficiently protective because of the presence of multiple contaminants or multiple pathways of exposure. For OU-1, both risk-based and ARAR-based PRGs are presented. These values are contrasted, where applicable, in Section 2.4.3.

Note that PRGs developed at this stage are considered initial goals which may be modified through the course of the CMS/FS. Following requirements established in the NCP, final remediation goals are not selected until the remedy selection phase of the CMS/FS. The ARARs presented in Section 2.4.1, as well as the risk-based PRGs, can be considered initial cleanup goals; however, exact criteria for final remediation will be selected as the CERCLA process proceeds. Either set of criteria could be used, a combination could be used, or revised PRGs could be used if necessary. The decision as to whether or not revised PRGs are required is based on the criteria described in the preamble to the NCP (55 Federal Register [FR] 8717, March 8, 1990) which states that,

> Preliminary remediation goals ... may be revised ... based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors.

Referring to the detailed analysis of alternatives, the preamble also states that,

> The final selection of the appropriate risk level is made when the remedy is selected based on the balancing criteria.

Generally, chemical-specific ARARs take precedence over risk-based PRGs, however, as noted above, final cleanup goals will depend on a variety of factors and will be agreed upon by the participating agencies (i.e., DOE, EPA, and the Colorado Department of Health [CDH]).

2.4.1 Potential Applicable or Relevant and Appropriate Requirements

Section 121(d)(2) of CERCLA provides a statutory basis for determining ARARs in a remedial action context. With respect to any hazardous substance, pollutant, or contaminant that will remain on site, Section 121(d)(2) of CERCLA states that,

> If any standard, requirement, criteria or limitation under any federal environmental law ... or any [stringent] promulgated standard, requirement, criteria or limitation under a state environmental or facility siting law . . . is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance, pollutant or contaminant, the remedial action shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance, pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria or limitation. 42 United States Code (USC) -----§ 9621(d)(2).

where "Applicable requirements" are those

> ... cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant or contaminant at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

According to the NCP and the *CERCLA Compliance with Other Laws Manual* (EPA 1988b),

> Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site so that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

The identification of chemical-specific ARARs was conducted in accordance with CERCLA guidance and the requirements of the National Contingency Plan (40 Code of Federal Regulations [CFR] Part 300.430(e)(2)(i)). Chemical-specific requirements under a variety of Federal and State laws were reviewed to evaluate which ones could be considered chemical-specific ARARs for OU-1. State of Colorado and Federal requirements were examined specific to the contaminants and media types at OU-1. The context of each requirement was also reviewed to evaluate its potential applicability or relevancy and appropriateness.

Potential chemical-specific ARARs for the groundwater medium beneath OU-1 are the Federal maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) promulgated under the Safe Drinking Water Act (40 CFR Parts 141 - 149). This interpretation was made for the following reasons:

1) The Federal Drinking Water Standards (MCLs) are considered relevant and appropriate but not applicable to the groundwater beneath OU-1. MCLs are not applicable because the groundwater beneath OU-1 is not currently utilized as a drinking water source and the nature of the hydrology is such that use of this water supply as a future source of drinking water is unlikely due to its seasonal presence as described in the RFI/RI. The Federal Drinking Water Standards are considered relevant and appropriate, however, according to the identification of ARARs that is required under Section 121(d) of CERCLA as amended, and are therefore chemical-specific ARARs for OU-1.

MCLGs are also required to be considered under Section 121(d) of CERCLA. It has been EPA's position that nonenforceable MCLGs established at zero are not appropriate for cleanup at a CERCLA site for a number of reasons (See EPA's comment and responses in the Preamble to Subpart E of NCP Final Rule - 55 FR 8751-8752). However, the use of non-zero MCLGs for cleanup of a site are to be considered according to the circumstances of the release and in cases involving multiple contaminants or pathways involving cumulative risk above 10^{-4}. Practical implementation of chemical-specific ARARs, therefore, assumes that MCLGs are also relevant and appropriate to the situation at OU-1.

2) Although the State of Colorado has adopted Classifications and Water Quality Standards for Groundwater-3.12.0 (Title 5 Colorado Code of Regulations [CCR] 1002-8) pursuant to 24-4-103(5) and 24-4-103(11) Colorado Revised Statutes (CRS), there is not an established permit program, including enforcement of rules, within the Water Quality Control Commission. Therefore, according to the criteria of 40 CFR 300.400(g)(4), the groundwater standards do not qualify as promulgated standards within the meaning of CERCLA.

3) The State of Colorado does have drinking water standards promulgated pursuant to CRS 25-1-107, 25-1-108, 25-1-109, and 25-1-114, and approved by EPA. However, a comparison of the State drinking water standards to the Federal Drinking Water Standards demonstrates that the State standards are not more stringent than the Federal standards. If drinking water standards are relevant and appropriate to the circumstances of clean-up, then the Federal standards should be the designated as chemical-specific ARARs according to 40 CFR 300.400 (g)(4).

4) The standards for groundwater protection under the RCRA regulations of 40 CFR 264.92 - 264.94 are similar to the requirements under the Safe Drinking Water Act. The RCRA standards use MCLs as the maximum concentration of constituents for groundwater in the uppermost aquifer. Selection of the MCLs under the Safe Drinking Water Act will serve the same or similar purpose as selection of the MCLs under the RCRA groundwater protection standards as a chemical-specific ARAR. RCRA groundwater protection standards are considered action-specific ARARs for any actions involving the groundwater beneath OU-1.

The COCs under consideration for OU-1 groundwater are identified in Table 2-3 along with their appropriate MCLs and MCLGs.

Soil-specific chemical requirements under State and Federal laws do not exist (i.e., there

Table 2-3.
Potential Groundwater ARARs
National Primary Drinking Water Standards[a]
(mg/L)

Contaminant	MCL[b]	MCLG[c]
Volatile Organic Compounds (VOCs)		
1,1-Dichloroethene	7×10^{-3}	7×10^{-3}
1,1,1-Trichloroethane	2×10^{-1}	2×10^{-1}
Carbon tetrachloride	5×10^{-3}	0
Tetrachloroethene	5×10^{-3}	0
Inorganics		
Selenium	5×10^{-2}	5×10^{-2}

[a]None of the listed COCs have an associated secondary or proposed MCL or proposed MCLG, although they would be TBCs if available.
[b]MCLs (from 40 CFR Part 141; effective 7/30/92) are considered relevant and appropriate.
[c]Non-zero MCLGs (from 40 CFR Part 141; effective 7/30/92) are considered relevant and appropriate and are equivalent to MCLs (see Section 2.4.1 for discussion).

are not any established protective levels for surface soil contamination based on risk to human health and/or the environment). There are, however, some chemical-specific guidelines and criteria available that specify waste concentration limits (e.g., RCRA delisting requirements or RCRA treatment standards specific to land disposal). These criteria and/or guidelines have been evaluated as TBCs.

One of the few requirements available for surface soil contamination is based on the State of Colorado's radiation control standards (6 CCR 1007-1, 4.19) which present a derived alpha activity limit for disposal of materials in soil (5 pCi/g). The derived alpha activity limit is an action-specific requirement according to EPA's guidance on identification of ARARs. In general, due to the lack of sufficient standards, a risk-based approach is suggested for establishing surface soil PRGs at OU-1.

2.4.2 <u>Preliminary Remediation Goals Based on 10^{-6} as the Point-of-Departure</u>

The methodology for implementing risk-based concentrations as PRGs is described in the NCP and the RI/FS guidance. Clarification of the 10^{-6} point-of-departure concept is also included in the preamble to the NCP and in the EPA's Office of Solid Waste and Emergency Response (OSWER) directive entitled, *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)* (EPA 1991a) (hereinafter referred to as the PRG guidance). In describing how the point-of-departure concept is applied for the development of PRGs, the directive explicitly states that for each chemical in a particular medium, "by setting the total risk for carcinogenic effects at a target risk level of 10^{-6}, ... it is possible to solve for the concentration term (i.e., risk-based PRG)." The "total risk" in this quote refers to the total risk summed across all pathways in a medium for a single chemical. For non-carcinogens, "the total risk for non-carcinogenic effects is set at a hazard index of 1 for each chemical in a particular medium."

Risk-based PRGs for OU-1 were calculated using the scenario where it is assumed that a hypothetical future on-site resident will ingest groundwater at the source. Originally, the following exposure routes for the future on-site resident were evaluated in the PHE:

- Inhalation of Indoor VOCs From Basement Vapor
- Inhalation of Particulates
- Soil Ingestion
- Dermal Contact with Soil
- Sediment Ingestion
- Dermal Contact with Sediment
- Surface Water Ingestion
- Dermal Contact with Surface Water
- Ingestion of Homegrown Vegetables/Fruit
- Groundwater Ingestion
- Dermal Contact with Groundwater
- Inhalation of VOCs from Indoor Water Use

Similarly, the following exposure routes for the future on-site commercial worker and ecological reserve researcher were evaluated in the PHE:

- Inhalation of Indoor VOCs From Basement Vapor (commercial worker only)
- Inhalation of Particulates
- Soil Ingestion
- Dermal Contact with Soil
- Sediment Ingestion
- Dermal Contact with Sediment
- Surface Water Ingestion
- Dermal Contact with Surface Water

Of the exposure routes listed above, those involving the media of surface water and sediments were not considered for PRG development as part of the OU-1 CMS/FS. These media are adjacent to OU-1 and will be addressed in OU-5. Additionally, these media do not present a risk greater than 10^{-6}, nor a hazard index greater than one, and therefore cannot be used for developing risk-based PRGs. Likewise, subsurface soils do not present a risk greater than 10^{-6}, nor a hazard index greater than one. For these reasons, only the media of surface soils and groundwater are addressed in the following calculations.

Groundwater PRG calculations are presented in the following order. First, risk equations are presented by pathway. Next, the equations are solved for concentration. And finally, a numerical example is presented. This sequence is repeated for surface soil PRG calculations. For both media, only the 10^{-6} value is used to calculate PRGs. Hazard Indices are not required because the carcinogenic toxicity of the OU-1 COCs outweigh the noncarcinogenic hazard (i.e., the carcinogenic risk value results in a more stringent PRG in all cases).

Groundwater PRGs were calculated using the following exposure routes:

- Groundwater Ingestion
- Dermal Contact with Groundwater
- Inhalation of VOCs from Indoor Water Use

The risk equations for these routes are presented below.

Groundwater Ingestion:

$$Risk = \frac{CW \times IR \times EF \times ED \times SF_o}{BW \times AT} \tag{1}$$

where:

CW	=	Chemical concentration in water (mg/liter)
IR	=	Ingestion rate (liter/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days)
SF_o	=	Oral slope factor $(mg/kg/day)^{-1}$

Dermal Contact with Groundwater:

$$\text{Risk} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF \times SF_o}{BW \times AT} \quad (2)$$

where:

CW	=	Chemical concentration in water (mg/liter)
SA	=	Skin surface area available for contact (cm^2)
PC	=	Chemical-specific dermal permeability constant (cm/hr)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Volumetric conversion factor for water (1 liter/1000 cm^3)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days)
SF_o	=	Oral slope factor $(mg/kg/day)^{-1}$

The surface area available for contact is dependent on the exposure media and pathway. Residents exposed to groundwater during showering are assumed to be exposed over their entire skin area.

Inhalation of VOCs from Indoor Water Use:

$$\text{Risk} = \frac{CA \times IR \times EF \times ED \times SF_i}{BW \times AT} \quad (3)$$

where:

CA	=	Contaminant concentration in air (mg/m^3)
IR	=	Inhalation rate (m^3/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days)
SF_i	=	Inhalation slope factor $(mg/kg/day)^{-1}$

These three equations may be combined and algebraically solved for the concentration:

$$CW = \frac{BW \times AT \times 1E{-}06}{EF \times ED \times [(IR + SA \times PC \times ET \times CF) \times SF_o + VF \times IR \times SF_i]} \tag{4}$$

where:

VF = volatilization factor (0.065 mg/m^3 in air per mg/ℓ in water)

For example, values pertinent to 1,1-dichloroethene were substituted into this expression, yielding a PRG of 8.82 x 10^{-2} ug/L (the parameters used below are valid for the future on-site resident scenario):

$$CW = \frac{70kg \times 25{,}550\ day \times 1E{-}06}{350\ \frac{day}{yr} \times 24\ yr} \times$$

$$\frac{1}{[(2\ \frac{\ell}{day} + 22{,}800\ cm^2 \times 1.6E{-}02\ \frac{cm}{hr} \times 0.2\ hr \times 0.001\ \frac{\ell}{cm^3}) \times 0.6\ (mg/kg/day)^{-1} + 0.065\ \frac{mg}{m^3}\ per\ \frac{mg}{\ell} \times 15\ \frac{m^3}{day} \times 1.2\ (mg/kg/day)^{-1}]} \tag{5}$$

$= 8.82\ E{-}02\ \mu g/\ell$

Groundwater PRGs which resulted from these calculations are presented in Table 2-4. Using similar methodology, soil PRGs were calculated with the following pathways:

- Inhalation of Particulates
- Soil Ingestion
- Ingestion of Homegrown Vegetables/Fruit

The risk equations for these exposure routes are shown for radionuclides. Note that radionuclide slope factors are not a function of body weight and averaging time.

Table 2-4.
Groundwater
Risk-Based Preliminary Remediation Goals (PRGs)[a]

Contaminant	Preliminary Remediation Goal by Scenario[b] (mg/L)	
	Future On-Site Resident	Commercial/ Industrial Worker
Volatile Organic Compounds (VOCs)		
1,1-Dichloroethene	8.8×10^{-5}	2.9×10^{-4}
1,1,1-Trichloroethane	3.1×10^{0}	c
Carbon Tetrachloride	6.6×10^{-4}	1.4×1^{-2}
Tetrachloroethene	1.85×10^{-3}	c
Inorganics		
Selenium	1.5×10^{-1}	c

[a]The numbers presented in this table are subject to change with the publication of the final RI/BRA.
[b]The ecological reserve researcher scenario does not apply to this medium.
[c]These contaminants did not result in a risk greater than 1×10^{-6}, nor a hazard index greater than one.

Inhalation of Particulates:

$$Risk = CS \times RD \times IR \times EF \times ED \times SF_i \qquad (6)$$

where:

CS = Contaminant concentration in soil (pCi/kg)
RD = Respirable dust concentration (3.6×10^{-7} kg/m^3)
IR = Inhalation rate (m^3/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF = Inhalation slope factor (pCi)$^{-1}$

Soil Ingestion:

$$Risk = CS \times IR \times CF \times EF \times ED \times SF_o \qquad (7)$$

where:

CS = Contaminant concentration in soil (pCi/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1×10^{-6} kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF = Inhalation slope factor (pCi)$^{-1}$

Ingestion of Homegrown Vegetables/Fruit:

$$Risk = CS \times UF \times IR \times EF \times ED \times SF_o \qquad (8)$$

where:

CS = Contaminant concentration in soil (pCi/kg)

UF = Plant uptake factor
IR = Ingestion rate (kg/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF_o = Inhalation slope factor $(pCi)^{-1}$

These three equations may be combined and algebraically solved for soil concentration:

$$CS = \frac{1E-06}{ED \times EF \times [(IR \times CF + IR \times UF) \times SF_o + RD \times IR \times SF_i]} \tag{9}$$

As a specific example, values pertinent to Pu-239,-240 are substituted into this expression, yielding a PRG of 3.54 x 10^{+2} pCi/kg:

$$CS = \frac{1E-06}{24\ yr \times 350\ \frac{day}{yr}} \times \tag{10}$$

$$\frac{1}{[(100\ \frac{mg}{day} \times 1E-06\ \frac{kg}{mg} + 0.078\ \frac{kg}{day} \times 2.23E-03) \times 2.3E-10\ \frac{1}{pCi} + 3.6E-07\ \frac{kg}{m^3} \times 20\ \frac{m^3}{day} \times 3.8E-08\ \frac{1}{pCi}]}$$

Risks for PAHs or Aroclor-1254 in surface soil for the primary pathway, soil ingestion, did not exceed 1 x 10^{-6}. For some of these contaminants, risks for a secondary pathway, plant ingestion, were estimated to be in the 10^{-5} range. However, these risks were not based on measured plant concentrations, but on plant concentrations estimated from soil concentrations. Furthermore, benzo(a)pyrene is the only PAH with a slope factor (EPA 1993), while slope factors for other PAHs are derived from benzo(a)pyrene based on estimated toxicity equivalence. In summary, the risk estimates for the plant ingestion pathway are based indirectly on soil concentrations and limited toxicity information, and are subject to greater uncertainty.

The PRGs for PAHs or Aroclor-1254 in surface soil were estimated using the plant ingestion portion of equation 10. Since these compounds are not radionuclides, body weight and averaging time were included in the numerator, similar to the way they appear in the equations for groundwater. Surface soil PRGs resulting from these calculations are presented in Table 2-5.

With regard to the commercial/industrial and ecological reserve researcher scenarios, PRGs were calculated for radionuclides, VOCs, PAHs, and PCBs in a similar manner (for the appropriate media). The key differences between calculating PRGs for residential and occupational scenarios is that occupational scenarios use an exposure duration of 25 years, an exposure frequency of 250 days/year, and a soil ingestion rate of 50 mg/day. Once again, the 1×10^{-6} risk level was used to calculate PRGs.

For radionuclides, the inhalation of particulates and ingestion of soil exposure routes were used to find surface soil PRGs. Equation 10 was used with the terms involving plant ingestion deleted. Inhalation of soil gas through the foundation was used to estimate groundwater PRGs for VOCs. PRGs were estimated by linearly reducing risk and groundwater concentrations until a concentration corresponding to a 1×10^{-6} level was reached. Since the soil-gas model may respond non-linearly in this region, the groundwater concentrations were checked by using them as input to the model and checking the resulting inhalation risks. The dermal contact pathway was used to derive PRGs for PAHs and PCBs. PRGs were estimated by linearly reducing risk and surface soil concentrations until a concentration corresponding to a 1×10^{-6} level was reached. These PRGs are also presented in Table 2-5.

Table 2-5.
Surface Soil
Risk-Based Preliminary Remediation Goals (PRGs)[a]

Contaminant	Preliminary Remediation Goal by Scenario[b] (mg/kg)	
	Future On-Site Resident	Commercial/ Industrial Worker
Polynuclear Aromatic Hydrocarbons (PAHs)		
Acenapthene	c	c
Benzo(a)anthracene	1.7×10^{-1}	c
Benzo(a)pyrene	1.6×10^{-1}	1.4×10^{-1}
Benzo(b)fluoranthene	c	c
Benzo(k)fluoranthene	c	c
Dibenzo(a,h)anthracene	1.7×10^{-2}	1.3×10^{-1}
Fluoranthene	c	c
Fluorene	c	c
Pyrene	c	c
Polychlorinated Biphenyls (PCBs)		
Aroclor-1254	5.0×10^{-2}	1.3×10^{-1}
Radionuclides[d]		
Americium-241	3.5×10^{-1}	6.6×10^{-1}
Uranium-233,-234	6.0×10^{-1}	8.2×10^{-1}
Uranium-238	3.1×10^{-1}	4.3×10^{-1}
Plutonium-239,-240	3.5×10^{-1}	5.6×10^{-1}

[a]The numbers presented in this table are subject to change with the publication of the final RI/BRA.
[b]The ecological reserve researcher scenario results in the same PRGs as the commercial/industrial worker scenario.
[c]These contaminants did not result in a risk greater than 1×10^{-6}, nor a hazard index greater than one.
[d]Radionuclides are reported in pCi/g.

2.4.3 Recommended Preliminary Remediation Goals

Based on the fact that groundwater MCLs are generally considered protective, and are chemical-specific ARARs for OU-1, these concentrations should be designated as initial PRGs for groundwater. If, at some point in the CERCLA process, it is determined that these goals cannot be achieved, then revised PRGs should be developed that will still provide an adequate level of protection, taking into account an appropriate future land use scenario for the RFP. For the purposes of the CMS/FS it is assumed that the future on-site resident scenario will be the scenario selected for PRGs.

Similarly, if it is determined that surface soils PRGs are technically impossible to achieve, then revision of these PRGs may be in order. Revised PRGs for surface soil would also be developed based on an appropriate future land use scenario. For both media, an administrative agreement would have to be made as to the level of protection considered acceptable for the revised PRGs. Table 2-6 presents a comparison of the risk-based PRGs, related ARARs (where appropriate), and existing contaminant concentrations for the COCs in the media of groundwater and surface soils. Surface soil PRGs presented in Table 2-6 are relevant to the hot spots which are being addressed in OU-1. Note that remedial action evaluation of the low-level plutonium contamination found in OU-1 (due to dispersion from the 903 Pad in OU-2), which will be addressed under OU-2, will automatically address the low-level PAH and PCB contamination found in the same area.

Table 2-6.
Comparison of Risk-Based PRGs, ARARs, and Existing Concentrations[a]

Contaminant	Existing Concentration		Risk-Based Preliminary Remediation Goal by Scenario[b]		ARARs[c]
	Sitewide w/out 119.1	IHSS 119.1	Future On-Site Resident	Commercial/ Industrial Worker	Federal MCLs
Groundwater (mg/L)					
1,1-Dichloroethene	1.62×10^{-3}	$5.96 \times 10^{+0}$	8.8×10^{-5}	2.9×10^{-4}	7×10^{-3}
1,1,1-Trichloroethane	1.63×10^{-3}	$7.27 \times 10^{+0}$	3.1×10^{0}	d	2×10^{-1}
Carbon Tetrachloride	7.98×10^{-3}	$1.84 \times 10^{+0}$	6.6×10^{-4}	1.4×1^{-2}	5×10^{-3}
Tetrachloroethene	3.10×10^{-3}	$2.03 \times 10^{+0}$	1.85×10^{-3}	d	5×10^{-3}
Selenium	1.32×10^{-1}	2.96×10^{-1}	1.5×10^{-1}	d	5×10^{-2}
Surface Soil (mg/kg; pCi/g for radionuclides)					
Acenapthene	1.94×10^{-1}	1.94×10^{-1}	d	d	
Benzo(a)anthracene	3.17×10^{-1}	3.17×10^{-1}	1.7×10^{-1}	d	
Benzo(a)pyrene	3.02×10^{-1}	3.02×10^{-1}	1.6×10^{-1}	1.4×10^{-1}	
Benzo(b)fluoranthene	3.05×10^{-1}	3.05×10^{-1}	d	d	
Benzo(k)fluoranthene	2.89×10^{-1}	2.89×10^{-1}	d	d	
Dibenzo(a,h)anthracene	1.88×10^{-1}	1.88×10^{-1}	1.7×10^{-2}	1.3×10^{-1}	
Fluoranthene	7.26×10^{-1}	7.26×10^{-1}	d	d	
Fluorene	1.92×10^{-1}	1.92×10^{-1}	d	d	
Pyrene	3.49×10^{-1}	3.49×10^{-1}	d	d	
Aroclor-1254	2.76×10^{-1}	2.76×10^{-1}	5.0×10^{-2}	1.3×10^{-1}	
Americium-241	5.73×10^{-1}	$2.22 \times 10^{+3}$	3.5×10^{-1}	6.6×10^{-1}	
Uranium-233,-234	1.30×10^{0}	$2.29 \times 10^{+1}$	6.0×10^{-1}	8.2×10^{-1}	
Uranium-238	1.28×10^{0}	4.66×10^{0}	3.1×10^{-1}	4.3×10^{-1}	
Plutonium-239,-240	3.42×10^{0}	$9.31 \times 10^{+3}$	3.5×10^{-1}	5.6×10^{-1}	

[a]COCs cannot be considered final until the results of the RI/BRA are formally published. The numbers presented in this table are subject to change with the publication of the final RI/BRA.
[b]The ecological reserve researcher scenario did not apply to the groundwater medium, and was equivalent to the commercial/industrial worker scenario for the surface soils medium.
[c]For OU-1, chemical-specific ARARs are only available for groundwater. In this case, for the COCs listed, Federal non-zero MCLGs are equivalent to MCLs.
[d]These contaminants did not result in a risk greater than 1×10^{-6}, nor a hazard index greater than one.

3.0 REFERENCES

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ATTACHMENT I

POTENTIAL SURFACE WATER ARARs

Runoff from contaminated soils and sediments was identified as a potential concern at OU-1. Woman Creek is a surface water body which could have been impacted by OU-1 contaminants, and was thus evaluated for risk in the OU-1 BRA. Because there was no significant risk associated with this medium (i.e., above 10^{-6}), and because it will be examined as part of OU-5, the medium of surface water is not subject to evaluation under OU-1. However, this attachment presents potential surface water ARARs for the contaminants found in OU-1, in order to assist the OU-5 ARARs assessment.

Sediment toxicity values are usually compared to water quality criteria established for specific basins and streams within water quality basins. This document identifies the State water quality criteria for human health (drinking water and fish ingestion) specific to the Woman Creek classification under the State's rules for Basic Standards and Methodologies for Surface Water 3.1.0 of 5 CCR 1002-8 and Classifications and Numeric Standards South Platte River Basin 3.8.0 of 5 CCR 1002-8. The State's water quality criteria established pursuant to both the Clean Water Act and State statutes are approved by EPA and are more stringent than Federal Water Quality Criteria. Accordingly, the attached table contains a list of the potential numeric surface water ARARs.

Potential Surface Water ARARs[a]
Water Quality Criteria - Human Health
(mg/L)

Contaminant	Federal	Colorado State-wide Standards			
	Water and Fish Ingestion	Water Supply	Water and Fish	Site Specific Domestic Water Supply Numeric Levels from Tables I, II, III[b]	Platte River CO Basin Standards[c] (Organics)
1,1-Dichloroethene	–	7×10^{3}	5.7×10^{-5}	–	–
1,1,1-Trichloroethane	$1.84 \times 10^{+1}$	2×10^{1}	2×10^{1}	–	–
Carbon Tetrachloride	4×10^{-4}	3×10^{-4}	2.5×10^{-4}	–	–
Tetrachloroethene	8×10^{-4}	5×10^{3}	8×10^{-4}	–	–
Toluene	$1.43 \times 10^{+1}$	1×10^{0}	1×10^{0}	–	–
Acenaphthene	–	–	–	–	–
Benzo(a)anthracene	–	–	2.8×10^{-6}	–	–
Benzo(a)pyrene	–	–	2.8×10^{-6}	–	–
Benzo(b)fluoranthene	–	–	2.8×10^{-6}	–	–
Benzo(k)fluoranthene	–	–	2.8×10^{-6}	–	–
Dibenz(a,h)anthracene	–	–	2.8×10^{-6}	–	–
Fluorathene	4.2×10^{2}	–	4.2×10^{-2}	–	–
Fluorene	–	–	2.8×10^{-6}	–	–
Pyrene	–	–	2.8×10^{-6}	–	–
Aroclor-1254	7.9×10^{8}	5×10^{-6}	4×10^{8}	–	–
Selenium	1×10^{2}	–	–	1×10^{2}	–
Americium-241	–	–	–	–	–
Uranium-233,-234	–	–	–	–	–
Uranium-238	–	–	–	–	–
Plutonium-239,-240	–	–	–	–	–

[a]Surface water and sediment remediation issues will be dealt with administratively under Operable Unit 5. These values are for information purposes only.
[b]Numeric levels used by Water Quality Commission to establish site-specific numeric standards when determined appropriate to protect the classified uses.
[c]Classifications and Numeric Standards for S. Platte River Basin (5 CCR 1002-8-3.8.0.)

Potential Surface Water ARARs[a]
Water Quality Criteria - Aquatic Life
(mg/L)

Contaminant	Federal		Colorado State-wide Standards				
	Aquatic Life		Aquatic Life		Site Specific Aquatic Life Numeric Levels from Tables I,II,III[b]		Platte River CO Basin Standards[c] (Organics)
	Chronic	Acute	Chronic	Acute	Chronic	Acute	
1,1-Dichloroethene	–	–	–	–	–	–	–
1,1,1-Trichloroethane	–	–	–	–	–	–	–
Carbon Tetrachloride	$3.52 \times 10^{+1}$	–	$3.52 \times 10^{+1}$	–	–	–	–
Tetrachloroethene	5.28×10^{0}	8.4×10^{-1}	5.28×10^{0}	8.4×10^{1}	–	–	–
Toluene	$1.75 \times 10^{+1}$	–	$1.75 \times 10^{+1}$	–	–	–	–
Acenaphthene	1.7×10^{0}	5.2×10^{-1}	1.7×10^{0}	5.2×10^{1}	–	–	–
Benzo(a)anthracene	–	–	–	–	–	–	–
Benzo(a)pyrene	–	–	–	–	–	–	–
Benzo(b)fluoranthene	–	–	–	–	–	–	–
Benzo(k)Fluoranthene	–	–	–	–	–	–	–
Dibenz(a,h)anthracene	–	–	–	–	–	–	–
Fluoranthene	3.98×10^{0}	–	3.98×10^{0}	–	–	–	–
Fluorene	–	–	–	–	–	–	–
Pyrene	–	–	–	–	–	–	–
Aroclor-1254	1.4×10^{5}	2×10^{3}	1.4×10^{5}	2×10^{5}	–	–	1×10^{12}
Selenium	2×10^{2}	5×10^{3}	–	–	1.35×10^{1}	1.7×10^{-2}	–
Americium-241	–	–	–	–	–	–	–
Uranium-233,-234	–	–	–	–	–	–	–
Uranium-238	–	–	–	–	–	–	–
Plutonium-239,-240	–	–	–	–	–	–	–

[a]Surface water and sediment remediation issues will be dealt with administratively under Operable Unit 5. These values are for information purposes only.
[b]Numeric levels used by Water Quality Commission to establish site-specific numeric standards when determined appropriate to protect the classified uses.
[c]Classifications and Numeric Standards for S. Platte River Basin (5 CCR 1002-8-3.8.0.)

Potential Surface Water ARARs[a]
Water Quality Criteria
Colorado Stream Segment Surface Water Quality Standards
(mg/L)

Contaminants	Stream Segment Table		Table 2 Radionuclides Woman Creek
	Acute	Chronic	
1,1-Dichloroethene	–	–	–
1,1,1-Trichloroethane	–	–	–
Carbon Tetrachloride	–	–	–
Tetrachloroethene	–	–	–
Toluene	–	–	–
Acenaphthene	–	–	–
Benzo(a)nthracene	–	–	–
Benzo(a)pyrene	–	–	–
Benzo(b)fluoranthene	–	–	–
Benzo(k)fluoranthene	–	–	–
Dibenz(a,h)anthracene	–	–	–
Fluoranthene	–	–	–
Fluorene	–	–	–
Pyrene	–	–	–
Aroclor-1254	–	7.9×10^{8}	–
Selenium	1×10^{2} (Total Recoverable)	–	–
Americium-241	–	–	–
Uranium-233,-234	–	–	5×10^{0} (total) pCi/L
Uranium-238	–	–	5×10^{0} (total) pCi/L
Plutonium-239,-240	–	–	5×10^{2} (total) pCi/L

[a]Surface water and sediment remediation issues will be dealt with administratively under Operable Unit 5. These values are for information purposes only.